APPLICATION FOR PATENT

TITLE: POWER CONTROL SYSTEMS AND METHODS FOR USE IN SATELLITE-BASED DATA COMMUNICATIONS SYSTEMS

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BACKGROUND OF THE INVENTION

[001] The present invention relates generally to satellite-based data communications systems and, more particularly, to power control systems for use with satellite modems and transmitter or transmitter/receiver (transceiver) units incorporated in such systems.

[002] When operating a satellite-based data communications system, it is often important that all communication signals received by a given satellite have similar strengths. One reason for this is that, if one signal reaching a satellite is significantly stronger than the other signals reaching the satellite, then the significantly stronger signal may interfere with the other signals and, in doing so, may cause data carried by the other signals to be corrupted.

[003] Although numerous phenomena (location in a beam, antenna pointing, etc.) may cause signal attenuation in satellite-based data communications systems, adverse weather is, perhaps, the most frequently encountered. The reason for this is that rain, clouds, and other adverse weather may cause signals transmitted by the transmitter or transceiver units of a satellite-based data communications system to be significantly attenuated and, thus, to have a reduced signal strength upon reaching a satellite.

[004] To compensate for weather-induced signal attenuation, many satellite-based data communications systems employ various types of power control feedback to adjust the level of communication signals radiated by earth stations. For example, typical power control systems allow transmission signal strengths to be increased during periods of bad

weather, thus compensating for any signal attenuation that may result from the weather. However, as is well known in the art, the input signal power that may be provided to a given transmitter or transceiver unit must be limited to prevent overdrive, which may cause the signals generated by the transmitter or transceiver unit to be significantly degraded. In short, if too much input signal power is provided to the power amplifier provided within a transmitter or transceiver unit, then the power amplifier may lose its ability to properly amplify signals and, in many instances, will generate significant amounts of in-band and out-of-band signal distortion. The in-band signal distortion may cause loss of communications connectivity on the link, and the out-of-band distortion may cause substantial interference with other signals being received by a satellite.

[005] Accordingly, it is an object of the present invention to provide an improved power control system for use with satellite-based data communications systems.

SUMMARY OF THE INVENTION

[006] In one innovative aspect, the present invention is directed to systems and methods for controlling an amount of input signal power to be provided to a transmitter or transceiver unit of a satellite-based data communications system by monitoring an amount of DC current provided to a power amplifier provided within the transmitter or transceiver unit, determining based upon a predetermined characteristic of the monitored DC current when additional input signal power to the power amplifier will drive the amplifier beyond its normal operating characteristics, and restricting the application of

additional input signal power to the power amplifier, when the monitored DC current exhibits the predetermined characteristic.

[007] In one preferred embodiment, the DC current provided to the power amplifier is monitored to determine when that current reaches a plateau, and following that point, no additional input signal power will be provided to the power amplifier of the transmitter or transceiver unit. In an alternative embodiment, the signal power may be adjusted by an automatic gain control or automatic level control circuit within the transmitter or transceiver unit when the monitored DC current begins to plateau.

[008] In another innovative aspect, the present invention is directed to systems and circuits for effecting the current monitoring and power regulation functions described above. In one such embodiment, a current monitor is utilized to directly monitor the DC current provided to an input of the power amplifier. The current monitor preferably is coupled to a comparator circuit, which in turn, is coupled to a telemetry circuit. The telemetry circuit then may be used to deliver power control data to a satellite modem, or other power regulation circuitry, associated with the transmitter or transceiver unit.

[009] As can be appreciated by those skilled in the art, the present invention not only addresses significant shortfalls in conventional power control system technology such as direct power measurement of a radio frequency signal, but also provides several new and innovative features. In particular, the present invention allows for satellite or satellite communications network initiated control of transmitter or transceiver unit input signal power output, while ensuring that the power amplifiers provided within those units are

not pushed beyond their normal or prescribed operating parameters. These and other advantages of the present invention are described more fully herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[010] Various objects and advantages of the present invention are apparent and more readily appreciated by reference to the following Detailed Description and to the appended claims when taken in conjunction with the accompanying Drawings, wherein:

FIGURE 1 illustrates a typical satellite-based data communications system employing at least one satellite, a plurality of ground-based transmitter or transceiver units, and a plurality of satellite modems associated with those units;

FIGURE 2 is a block diagram illustrating one embodiment of a power regulation control circuit in accordance with the present invention;

FIGURE 3 is a block diagram illustrating a second embodiment of a power regulation control circuit in accordance with the present invention; and

FIGURE 4 is a graph illustrating a relationship between an amount of DC input current that may be drawn by a typical power amplifier and the power output of the amplifier, as an amount of power input to the amplifier is increased.

DETAILED DESCRIPTION

[011] Figure 1 provides an illustration of a typical satellite-based data communications system 100 that includes at least one satellite 105, a plurality of transmitter or transceiver units 110(a)-(c), and a plurality of satellite modems (not shown) associated with the transmitter or transceiver units 110(a)-(c). To simplify the discussion herein, the term "transmitter unit" shall be used hereafter to refer to both transmitter units and transceiver units.

[012] As explained above, it is desirable to balance the intensities of all of the communication signals S1, S2, and S3 received by the satellite 105, so that the signals S1, S2, and S3 do not interfere with one another. This is particularly important when, for example, one of the signals (e.g., signal S3) must travel through a dense rain cell 115, or other adverse weather conditions. When that occurs, the signal S3 passing through the rain cell 115 may be significantly attenuated, making reception of that signal more difficult, and increasing the likelihood that signals S1 and S2 will interfere with proper reception of the signal S3.

[013] To compensate for the attenuation of signal S3 that results from the rain cell 115, it may be desirable to increase the input signal power provided to the transmitter unit 110(c), thereby increasing the initial strength of signal S3, and allowing signal S3 to be balanced with signals S1 and S2 upon receipt by the satellite 105. To provide for such an increase in transmission signal strength, the satellite 105 or satellite communications network through satellite 105 may simply monitor the relative strengths of the signals

that it receives and communicate, as appropriate, messages to any transmitter units 110(a)-(c) that need to increase their power output.

[014] The above described technique for balancing signal strengths is useful, until the power amplifier circuits 240 (shown in Figures 2 and 3) are forced to exceed their normal or prescribed operating characteristics. When this occurs, the quality of the output signals generated by the power amplifier circuits 240 degrades significantly, and substantial interference with other signals often results. Thus, it is important to control the amount of power applied to the amplifier circuits 240 provided within the transceiver units 110(a)-(c), to ensure that those circuits are not overdriven and forced to operate outside of their normal or prescribed zones of operation.

[015] In one particularly innovative aspect, the present invention is directed to systems and methods for ensuring that the power amplifier circuits 240 provided within the transmitter units 110(a)-(c) are not forced to operate outside of their normal range of operation and into overdrive. Exemplary embodiments of such a system are illustrated in Figures 2 and 3.

[016] Turning now to Figure 2, a power regulation system 200 in accordance with the present invention may comprise a satellite modem 210 and associated DC power source 215, a coaxial cable 220 or other communications conduit connecting the satellite modem 210 to a transmitter unit 110, and the transmitter unit 110. In a preferred form, a current monitor 245 is used to monitor a characteristic of a DC current that is provided by a DC current regulator circuit 225 to an input of a power amplifier circuit 240 of the transmitter

unit 110. The current sensor 245 may be coupled to a comparator circuit 250, and the comparator circuit 250 may be coupled to a telemetry circuit 255 such that data descriptive of the characteristic of the monitored DC current may be provided, for example, over another coaxial cable 260 or other communications conduit to a power regulator (not shown) of the DC power source 215.

[017] Because the current input to the power amplifier 240 will exhibit a predetermined characteristic, e.g., will plateau, as the power amplifier 240 approaches an upper limit of its range of operation, it is possible to limit the amount of power that is applied to the transmitter unit 110 upon detection of that characteristic. This characteristic is illustrated in Figure 4. Thus, depending upon the circumstances of operation, it may be desirable to cap or limit the amount of input signal power provided to the transmitter unit 110, when the prescribed current characteristic is detected by the current monitor 245 and related circuits 250 and 255. In this fashion, a satellite or satellite communications network may be prevented from overdriving a transmitter unit 110 beyond its operational thresholds during periods of increased link attenuation.

[018] Those skilled in the art will appreciate that, because the bulk of the power consumed by a typical transmitter unit 110 will be consumed by the power amplifier 240 provided within the transmitter unit 110, it is possible to monitor the DC current provided to the power amplifier 240 either directly, as described above, or indirectly. Indeed, after being made aware of the system described above, others have suggested that by monitoring the amount of DC current that is generated by the DC current regulator 225, it

is possible to obtain a close approximation of the DC current applied to the power amplifier 240, and it is possible to determine when the overall current generated by that regulator 225 exhibits a characteristic indicating that the power amplifier is approaching its operating limits.

[019] Similarly, as illustrated in Figure 3, in alternative embodiments developed by others familiar with the present invention, it may be desirable to monitor a DC current component of a signal carried on the coaxial cable 220 or other transmission conduit to determine when the power amplifier 240 is approaching its operating limits. Although this embodiment employs virtually the same circuitry that is used in the embodiment illustrated in Figure 2, this embodiment reduces the amount of signal communication that must be supported between the satellite modem 210 and the transmitter unit 110.

[020] Those skilled in the art will appreciate, therefore, that it is possible and, indeed, equivalent to monitor either directly or indirectly the DC current that is provided to the power amplifier 240 of the transmitter unit 110 to ensure that the amplifier 240 is not pushed beyond its normal or prescribed operating limits.

[021] Because the invention is susceptible to various modifications and alternative forms, specific examples thereof have been shown in the drawings and are herein described in detail. It should be understood, however, that the invention is not to be limited to the particular forms or methods disclosed, but to the contrary, the invention should encompass all modifications, alternatives, and equivalents falling within the spirit and scope of the appended claims.